Annex 3 - Appendix B
(Not allocated)

Annex 3 - Appendix C

(Not allocated)

Annex 3 - Appendix D

REPORT FORMS

NOTE - This appendix is not a mandatory part of this annex.

The following forms should be used:

(1) Report of Manufacture & Certificate of Conformance - Required to be clear, legible and in the format of Form 1:

(2) Report 1/ of Chemical Analysis of Material for Metallic Cylinders, Liners, or Bosses - Required essential elements, identification, etc.

(3) Report 1/ of Mechanical Properties of Material for Metallic Cylinders and Liners - Required to report all tests required by this Regulation.

(4) Report 1/ of Physical and Mechanical Properties of Materials for Non Metallic Liners - Required to report all tests and information required in this Regulation.

(5) Report 1/ of Composite Analysis - Required to report all tests and data required in this Regulation.

(6) Report of Hydrostatic Tests, Periodic Pressure Cycling and Burst Tests - Required to report test and data required in this Regulation.

1/ Report forms 2 through 6 shall be developed by the manufacturer and must fully identify cylinders and requirements. Each report shall be signed by the Competent Authority and the manufacturer.

Form 1: Report of Manufacturer and Certification of Conformance

Manufactured by:

Located at:

Regulatory Registration Number:

Manufacturers Mark and Number:

Serial Number: from ..... to ..... inclusive

Cylinder description:

SIZE: Outside diameter: ..... mm; Length: .....mm;

Marks stamped on shoulder or on labels of the cylinder are:

(a) "CNG ONLY": . . . . . .
(b) "DO NOT USE AFTER": . . . . . .
(c) Manufacturer's mark: . . . . . .
(d) Serial or part number: . . . . . .
(e) Working pressure in MPa: . . . . . .
(f) ECE Regulation: . . . . . .
(g) Fire protection type: . . . . . .
(h) Date of original test (month & year): . . . . . .
(i) Tare mass of empty cylinder (in kg): . . . . . .
(j) Authorized Body or Inspectors Mark: . . . . . .
(k) Water capacity in L: . . . . . .
(l) Test pressure in MPa: . . . . . .
(m) Any special instructions: . . . . . .

Each cylinder was made in compliance with all requirements of ECE Regulation No. ... in accordance with the cylinder description above. Required reports of test results are attached.
I hereby certify that all these test results proved satisfactory in every way and are in compliance with the requirements for the type listed above.

Comments :

Competent Authority: Inspector's signature: Manufacturer's signature:

Place, Date: . . . . . .

Annex 3 - Appendix E

VERIFICATION OF STRESS RATIOS USING STRAIN GAUGES

1. The stress-strain relationship for fibres is always elastic, therefore, stress ratios and strain ratios are equal.

2. High elongation strain gauges are required.

3. Strain gauges should be orientated in the direction of the fibres on which they are mounted (i.e. with hoop fibre on the outside of the cylinder, mount gauges in the hoop direction).

4. Method 1 (applies to cylinders that do not use high tension winding)

   (a) Prior to auto-frettage, apply strain gauges and calibrate;

   (b) Measure strains at auto-frettage, zero after auto-frettage, working, and minimum burst pressure have been met;

   (c) Confirm that the strain at burst pressure divided by strain at working pressure meets the stress ratio requirements. For hybrid construction, the strain at working pressure, is compared with the rupture strain of cylinders reinforced with a single fibre type.

5. Method 2 (applies to all cylinders)

   (a) At zero pressure after winding and auto-frettage, apply strain gauges and calibrate;

   (b) Measure strains at zero, working, and minimum burst pressure;

   (c) At zero pressure, after strain measurements have been taken at the working and minimum burst pressures, and with strain gauges monitored, cut the cylinder section apart so that the region containing the strain gauge is approximately five inches long. Remove the liner without damaging the composite. Measure the strains after the liner is removed.

   (d) Adjust the strain readings at zero, working, and minimum burst pressures by the amount of strain measured at zero pressure with and without the liner.

   (e) Confirm that the strain at burst pressure divided by strain at working pressure meets the stress ratio requirements. For hybrid construction, the strain at working pressure is compared with the rupture strain of cylinders reinforced with a single fibre type.

Annex 3 - Appendix F

FRACTURE PERFORMANCE METHODS

F.1. Determination of fatique sensitive sites

The location and orientation of fatigue failure in cylinders shall be determined by appropriate stress analysis or by full scale fatigue tests on finished cylinders as required under the design qualification tests for each type of design. If finite element stress analysis is used, the fatigue sensitive site shall be identified based on the location and orientation of the highest tensile principal stress concentration in the cylinder wall or liner at the working pressure.

F.2. Leak-Before-Break (LBB)

F.2.1. Engineering critical assessment This analysis may be carried out to establish that the finished cylinder will leak in the event of a defect in the cylinder or liner growing into a through-wall crack. A leak-before-break assessment shall be performed at the cylinder side wall. If the fatigue sensitive location is outside the side wall, a leak-before-break assessment shall also be performed at that location using a Level II approach as outlined in BS PD6493. The assessment shall include the following steps:

(a) Measure the maximum length (i.e. major axis) of the resultant through-wall surface crack (usually elliptical in shape) from the three cylinder cycle tested under the design qualification tests (according to paragraphs A.13 and A.14 of appendix A) for each type of design. Use the longest crack length of the three cylinders in the analysis. Model a semi-elliptical through-wall crack with a major axis equal to twice the measured longest major axis and with a minor axis equal to 0.9 of wall thickness. The semi-elliptical crack shall be modelled at the locations specified in paragraph F.1. of appendix F. The crack shall be oriented such that the highest tensile principal stress shall drive the crack;

(b) Stress levels in the wall/liner at 26 MPa obtained from the stress analysis as outlined in paragraph 6.6 of annex 3 shall be used for the assessment. Appropriate crack driving forces shall be calculated using either Section 9.2 or 9.3 of BS PD6493;

(c) Fracture toughness of the finished cylinder or the liner from a finished cylinder, as determined at room temperature for aluminium and at -40 °C for steel, shall be established using a standardized testing technique (either ISO/DIS 12737 or ASTM 813-89 or BS 7448) in accordance with Sections 8.4 and 8.5 of BS PD6493;

(d) Plastic collapse ratio shall be calculated in accordance with Section 9.4 of BS PD6493-91;

(e) The modelled flaw shall be acceptable in accordance with Section 11.2 of BS PD6493-91.

F.2.2. LBB by flawed cylinder burst

A fracture test shall be performed by the cylinder side wall. If the fatigue sensitive locations as determined in paragraph F.1. (appendix F) is outside the side wall, the fracture test shall also be performed at that location. The test procedure is as follows:

(a) Determination of leak-before-break flaw length

The length of the LBB flaw at the fatigue sensitive site shall be twice the length of the maximum length measured of the resultant through-wall surface crack from the three cylinders cycle tested to failure under the design qualification tests for each type of design;

(b) Cylinder flaws

For type CNG-1 designs having fatigue sensitive site in the cylindrical part in the axial direction, external flaws shall be machined longitudinally, approximately at mid-length of the cylindrical part of the cylinder. The flaws shall be located at minimum wall thickness of the midsection based on thickness measurements at four points around the cylinder. For type CNG-1 designs having fatigue sensitive site outside the cylindrical part, the LBB flaw shall be introduced at the internal surface of the cylinder along the fatigue sensitive orientation. For type CNG-2 and CNG-3 designs the LBB flaw shall be introduced in the metal liner;

For flaws to be tested by monotonic pressure, the flaw cutter shall be approximately 12.5 mm thick with an angle of 45 °C and a tip radius of 0.25 mm maximum. The cutter diameter shall be 50 mm for cylinder with outside diameter less than 140 mm, and 65 to 80 mm for cylinders with outside diameter greater than 140 mm (A standard CVN cutter is recommended).

NOTE - The cutter should be sharpened regularly to assure tip radius meets specification.

The depth of the flaw may be adjusted to obtain a leak by monotonic hydro-pressurization. The crack shall not propagate by more than 10 per cent outside of the machined flaw measured on the external surface:

(c) Test procedure

The test shall be performed by monotonic pressurisation or cyclic pressurisation as described below:

(i) Monotonic pressurisation to burst

The cylinder shall be pressurised hydrostatically until pressure is released from the cylinder at the flaw location. The pressurisation shall be performed as described in paragraph A.12. (appendix A);

(ii) Cyclic pressure

The test procedure shall be in accordance with the requirements of paragraph A.13. of appendix A.

(d) Acceptance criteria for the flawed cylinder test

The cylinder passes the tests if the following conditions are met:

(i) For monotonic pressurisation burst test, the failed pressure shall be equal or greater than 26 MPa;

For monotonic pressurised burst test, a total crack length measured on the external surface of 1.1 times the original machined length is allowed.

(ii) For cycle tested cylinders, fatigue crack growth beyond the original machined flaw length is allowed. However, the failure mode must be a "leak". Propagation of the flaw by fatigue should occur over at least 90 per cent of the length of the original machined flaw;

NOTE - If these requirements are not fulfilled (failure occurs below 36 MPa, even and if the failure is a leak), a new test can be performed with a less deep flaw. Also, if rupture type failure occurs at a pressure greater than 26 MPa and flaw depth is shallow, a new test can be performed with a deeper flaw.

F.3. Defect size for non-destructive examination (NDE)

F.3.1. NDE Defect size by engineering critical assessment

Calculations shall be performed in accordance with British Standard (BS) PD 6493, Section 3, using the following steps:

(a) Fatigue cracks shall be modelled at the high stress location in the wall/liner as planar flaws;

(b) The applied stress range at the fatigue sensitive site, due to a pressure between 2 MPa and 20 MPa, shall be established from the stress analysis as outlined in paragraph F.1. of appendix F;

(c) The bending and membrane stress component may be used separately;

(d) The minimum number of pressure cycles is 15,000;

(e) The fatigue crack propagation data shall be determined in air in accordance with ASTM E647. The crack plane orientation shall be in the C-L direction (i.e., crack plane perpendicular to the circumferences and along the axis of the cylinder), as illustrated in ASTM E399. The rate shall be determined as an average of 3 specimen tests. Where specific fatigue crack propagation data are available for the material and service condition, they may be used in the assessment.

(f) The amount of crack growth in the thickness direction and in the length direction per pressures cycle shall be determined in accordance with the steps outlined in Section 14.2 of the BS PD 6493-91 standard by integrating the relationship between the rate of fatigue crack propagation, as established in e) above, and the range of crack driving force corresponding to the applied pressure cycle;

(g) Using the above steps, calculate the maximum allowable defect depth and length which shall not cause the failure of the cylinder during the design life due to either fatigue or rupture. The defect size for NDE shall be equal to or less than the calculated maximum allowable defect size for the design.

F.3.2. NDE Defect size by flawed cylinder cycling

For type CNG-1, CNG-2 and CNG-3 designs, three cylinders containing artificial defects that exceed the defect length and depth detection capability of the NDE inspection method required in paragraph 6.15. of annex 3, shall be pressure cycled to failure in accordance with the test method in paragraph A.13 (appendix A). For type CNG-1 designs having a fatigue sensitive site in the cylindrical part, external flaws shall be introduced on the side wall. For type CNG-1 designs having the fatigue sensitive site outside the side wall, and for type CNG-2 and CNG-3 designs, internal flaws shall be introduced. Internal flaws may be machined prior to the heat treating and closing of the end of the cylinder.

The cylinders shall not leak or rupture in less than 15,000 cycles; The allowable defect size for NDE shall be equal to or less than the artificial flaw size at that location.

Annex 3 - Appendix G

INSTRUCTIONS BY THE CONTAINER MANUFACTURER REGARDING HANDLING, USE AND INSPECTION OF CYLINDERS

G.1. General

The primary function of this appendix is to provide guidance to the cylinder purchaser, distributor, installer and user for the safe use of the cylinder over its intended service life.

G.2. Distribution

The manufacturer shall advise the purchaser that the instructions shall be supplied to all parties involved in the distribution, handling, installation and use of the cylinders; The document may be reproduced to provide sufficient copies for this purpose, however it shall be marked to provide reference to the cylinders being delivered;

G.3. Reference to existing codes, standards and regulations

Specific instructions may be stated by reference to national or recognised codes, standards and regulations.

G.4. Cylinder handling

Handling procedures shall be provided to ensure that the cylinders will not suffer unacceptable damage or contamination during handling.

G.5. Installation

Installation instructions shall be provided to ensure that the cylinders will not suffer unacceptable damage during installation and during normal operation over the intended service life.

Where the mounting is specified by the manufacturer, the instructions shall contain where relevant, details such as mounting design, the use of resilient gasket materials, the correct tightening torques and avoidance of direct exposure of the cylinder to an environment of chemical and mechanical contacts.

Where the mounting is not specified by the manufacturer, the manufacturer shall draw the purchaser's attention to possible long term impacts of the vehicle mounting system, for example: vehicle body movements and cylinder expansion/contraction in the pressure and temperature conditions of service.

Where applicable, the purchaser's attention shall be drawn to the need to provide installations such that liquids or solids cannot be collected to cause cylinder material damage;

The correct pressure relieve device to be fitted shall be specified.

G.6. Use of cylinders

The manufacturer shall draw the purchaser's attention to the intended service conditions specified by this Regulation, in particular the cylinder's allowable number of pressure cycles. its life in years, the gas quality limits and the allowable maximum pressures.

G.7. In-service inspection

The manufacturer shall clearly specify the user's obligation to observe the required cylinder inspection requirements (e.g. reinspection interval, by authorised personnel). This information shall be in agreement with the design approval requirements.

Annex 3 - Appendix H

ENVIRONMENTAL TEST

H.1. Scope

The environmental test is intended to demonstrate that NGV cylinders can withstand exposure to the automotive underbody environment and occasional exposure to other fluids. This test was developed by the US automotive industry in response to cylinder failures initiated by stress corrosion cracking of the composite wrap.

H.2. Summary of test method

A cylinder is first preconditioned by a combination of pendulum and gravel impacts to simulate potential underbody conditions. The cylinder is then subjected to a sequence of immersion in simulated road salt/acid rain, exposure to other fluids, pressure cycles and high and low temperature exposures. At the conclusion of the test sequence the cylinder will be hydraulically pressured to destruction. The remaining residual burst strength of the cylinder shall be not less than 85 per cent of the minimum design burst strength.

H.3. Cylinder set-up and preparation

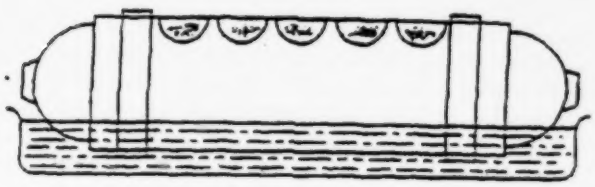
The cylinder shall be tested in a condition representative of installed geometry including coating (if applicable), brackets and gaskets, and pressure fittings using the same sealing configuration (i.e. O-rings) as that used in service. Brackets may be painted or coated prior to installation in the immersion test if they are painted or coated prior to vehicle installation.

Cylinders will be tested horizontally and nominally divided along their horizontal centreline into "upper" and "lower" sections. The lower section of the cylinder will be alternatively immersed in road salt/acid rain environment and in heated or cooled air.

The upper section will be divided into 5 distinct areas and marked for preconditioning and fluid exposure. The areas will be nominally 100 mm in diameter. The areas shall not overlap on the cylinder surface. While convenient for testing, the areas need not be oriented along a single line, but must not overlap the immersed section of the cylinder.

Although preconditioning and fluid exposure is performed on the cylindrical section of the cylinder, all of the cylinder, including the domed sections, should be as resistant to the exposure environments as are the exposed areas.

Other fluid
exposure areas



Immersion area
(lower third)

Figure H.1 - Cylinder orientation and layout of exposure areas

H.4. Preconditioning apparatus

The following apparatus are needed for preconditioning the test cylinder by pendulum and gravel impact.

(a) Pendulum impact

The impact body shall be of steel and have the shape of a pyramid with equilateral triangle faces and a square base, the summit and the edges being rounded to a radius of 3 mm. The centre of percussion of the pendulum shall coincide with the centre of gravity of the pyramid; its distance from the axis of rotation of the pendulum shall be 1 m. The total mass of the pendulum referred to its centre of percussion shall be 15 kg. The energy of the pendulum at the moment of impact shall be not less than 30 Nm and as close to that value as possible.

During pendulum impact, the cylinder shall be held in position by the end bosses or by the intended mounting brackets.

(b) Gravel impact

Machine constructed according to the design specifications shown in figure H.2.This procedure for operation of the equipment shall follow that described in ASTM D3170, Standard Test Method for Chip Resistance of Coatings with the exception that the cylinder may be at ambient temperature during gravel impact;

(c) Gravel

Alluvial road gravel passing through a 16 mm space screen but retained on a 9.5 mm space screen. Each application is to consist of 550 ml of graded gravel (approx. 250 to 300 stones).

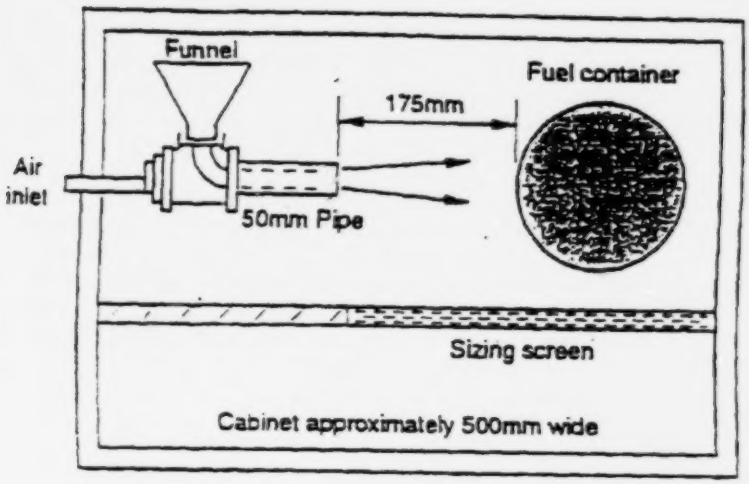


Figure H.2 - Gravel impact test

H.5. Exposure environments

(a) Immersion environment

At the specified stage in the test sequence (table 1) the cylinder will be oriented horizontally with the lower third of the cylinder diameter immersed in a simulated acid rain/road salt water solution. The solution will consist of the following compounds:

Deionized water;	
Sodium chloride:	2.5 per cent by weight ± 0.1 per cent;
Calcium chloride:	2.5 per cent by weight ± 0.1 per cent;
Sulfuric acid:	Sufficient to achieve a solution pH of 4.0 ± 0.2;

Solution level and pH are to be adjusted prior to each test step which uses this liquid.

The temperature of the bath shall be 21 ± 5 °C. During immersion, the unsubmerged section of the cylinder shall be in ambient air.

b) Other fluid exposure

At the appropriate stage in test sequence (table 1) each marked area is to be exposed to one of five solutions for 30 minutes. The same environment shall be used for each location throughout the test. The solutions are:

Sulfuric acid:	19 per cent solution by volume in water;
Sodium hydroxide:	25 per cent solution by weight in water;
Methanol/gasoline:	30/70 per cent concentrations;
Ammonium nitrate:	28 per cent by weight in water;
Windshield washer fluid.	

When exposed, the test sample will be oriented with the exposure area uppermost. A pad of glass wool one layer thick (approximately 0.5 mm) and trimmed to the appropriate dimensions is to be placed on the exposure area. Using a pipet, apply 5 ml of the test fluid to the exposure area. Remove the gauze pad after pressurization of the cylinder for 30 minutes.

H.6. Test conditions

(a) Pressure cycle

As defined in the test sequence, cylinder shall be hydraulically pressure cycled between not more than 2 MPa and not less than 26 MPa. The total cycle shall be not less than 66 seconds and will include a 60 second minimum hold at 26 MPa. The nominal cycle process will be:

Ramp up from ≤ 20 MPa to > 26 MPa;
Hold at ≥ 26 MPa for 60 seconds minimum;
Ramp down from ≥ 26 MPa to ≤ 2 MPa;
Total minimum cycle time to be 66 seconds.

(b) Pressure during other fluid exposure

Following application of the other fluids, the cylinder shall be pressured to not less than 26 MPa for a minimum of 30 minutes;

(c) High and low temperature exposure

As defined in the test sequence, the entire cylinder shall be exposed to high or low temperature air in contact with external surface. The low temperature air shall be -40 °C or lower and the high temperature air shall be 82 °C ± 5 °C. For the low temperature exposure, the fluid temperature of type CNG-1 cylinders shall be monitored using a thermocouple installed within the cylinder to ensure it remains at -40 °C or lower.

H.7. Test procedure

(a) Preconditioning of the cylinder

Each of the five areas marked for other fluid exposure an the upper section of the cylinder shall be preconditioned by a single impact of the pendulum body summit at their geometric centre. Following impact, the five areas shall be further conditioned by a gravel impact application.

The central section of the bottom portion of the cylinder that will be submerged shall be preconditioned by an impact of the pendulum body summit at three locations spaced approximately 150 mm apart.

Following impact, the same central section that was impacted shall be further conditioned by a gravel impact application.
The cylinder shall be unpressured during preconditioning.

(b) Test sequence and cycles

The sequence of the environment exposure, pressure cycles, and temperature to be used are defined in table 1.

The cylinder surface is not to be washed or wiped between stages.

H.8. Acceptable results

Following the above test sequence, the cylinder shall be hydraulically tested to destruction in accordance with the procedure in paragraph A.12. The burst pressure of the cylinder shall be not less than 85 per cent of the minimum design burst pressure.

Table H.1 - Test conditions and sequence

Test steps	Exposure environments	Number of pressure cycles	Temperature
1	Other fluids	--	Ambient
2	Immersion	1875	Ambient
3	Air	1875	High
4	Other fluids	--	Ambient
5	Immersion	1875	Ambient
6	Air	3750	Low
7	Other fluids	--	Ambient
8	Immersion	1875	Ambient
9	Air	1875	High
10	Other fluids	--	Ambient
11	Immersion	1875	Ambient

Annex 4A

PROVISIONS REGARDING THE APPROVAL OF THE AUTOMATIC VALVE, CHECK VALVE, THE PRESSURE RELIEF VALVE, PRESSURE RELIEF DEVICE AND THE EXCESS FLOW VALVE

1. The purpose of this annex is to determine the provisions regarding the approval of the automatic valve, the check valve, the pressure relief valve, the pressure relief device and the excess flow valve.

2. The automatic valve

2.1. The materials constituting the automatic valve which are in contact with the CNG when operating, shall be compatible with the test CNG. In order to verify this compatibility the procedure described in annex 5D shall be used.

2.2. Operating specifications

2.2.1. The automatic valve shall be so designed as to withstand a pressure of 1.5 times the working pressure (MPa) without leakage and deformation.

2.2.2. The automatic valve shall be so designed as to be leak-proof at a pressure of 1.5 times the working pressure (MPa) (see annex 5B).

2.2.3. The automatic valve, being in the normal position of use specified by the manufacturer, is submitted to 20,000 operations; then it is deactivated. The automatic valve shall remain leak-proof at a pressure of 1.5 times the working pressure (MPa) (see annex 5B).

2.2.4. The automatic valve shall be so designed to operate at temperatures as specified in annex 5O.

2.3. The electrical system, if existing, shall be isolated from the body of the automatic valve. Isolation resistance shall be > 10 MΩ.

2.4. The automatic valve activated by an electric current shall be in a "closed" position when the current is switched off.

2.5. The automatic valve has to comply with the test procedures for the Class component determined according to the scheme in Figure 1-1 of paragraph 2 of this Regulation.

3. The check valve

3.1. The materials constituting the check valve which are in contact with the CNG when operating, shall be compatible with the test CNG. In order to verify this compatibility the procedure described in annex 5D shall be used.

3.2. Operating specifications

3.2.1. The check valve shall be so designed as to withstand a pressure of 1.5 times the working pressure (MPa) without leakage and deformation.

3.2.2. The check valve shall be so designed as to be leak-proof (external) at a pressure of 1.5 times the working pressure (MPa) (see annex 5B).

3.2.3. The check valve, being in the normal position of use specified by the manufacturer, is submitted to 20,000 operations; then it is deactivated. The check valve shall remain leak-proof (external) at a pressure of 1.5 times the working pressure (MPa) (see annex 5B).

3.2.4. The check valve shall be so designed to operate at temperatures as specified in annex 5O.

3.3. The check valve has to comply with the test procedures for the Class component determined according to the scheme in Figure 1-1 of paragraph 2 of this Regulation.

4. <u>The pressure relief valve and pressure relief device</u>

4.1. The materials constituting the pressure relief valve and pressure relief device which are in contact with the CNG when operating, shall be compatible with the test CNG. In order to verify this compatibility, the procedure described in annex 5D shall be used.

4.2. Operating specifications

4.2.1. The pressure relief valve and pressure relief device in Class 0 shall be so designed as to withstand a pressure of 1.5 times the working pressure (MPa).

4.2.2. The pressure relief valve and pressure relief device of Class 1 shall be so designed as to be leak-proof at a pressure of 1.5 times the working pressure (MPa) with the outlet closed off (see annex 5B).

4.2.3. The pressure relief valve of Class 1 and Class 2 shall be so designed as to be leak-proof at twice the working pressure with the outlets closed off.

4.2.4. The pressure relief device shall be so designed to open the fuse at a temperature of 110 ± 10 °C.

4.2.5. The pressure relief valve of Class 0 shall be so designed to operate at temperatures from -40 °C to 85 °C.

4.3. The pressure relief valve and pressure relief device have to comply with the test procedures for the Class component determined according to the scheme in Figure 1-1 of paragraph 2 of this Regulation.

5. The excess flow valve

5.1. The materials constituting the excess flow valve which are in contact with the CNG when operating, shall be compatible with the test CNG. In order to verify this compatibility, the procedure described in annex 5D shall be used.

5.2. Operating specifications

5.2.1. The excess flow valve, if it is not integrated in the cylinder, shall be so designed as to withstand a pressure of 1.5 times the working pressure (MPa).

5.2.2. The excess flow valve shall be so designed as to be leak-proof at a pressure of 1.5 times the working pressure (MPa).

5.2.3. The excess flow valve shall be so designed to operate at temperatures as specified in annex 5O.

5.3. The excess flow valve shall be mounted inside the container.

5.4. The excess flow valve shall be designed with a bypass to allow for equalization of pressures.

5.5. The excess flow valve shall cut off at a pressure difference over the valve of 90 kPa. At this pressure difference the flow shall not exceed 8,000 cm^3 per minute.

5.6. When the excess flow valve is at cut-off position, the flow through the by-pass shall not exceed 500 cm^3/min. at a differential pressure of 700 kPa.

5.7. The device have to comply with the test procedures for the Class components, specified in the scheme in Figure 1-1 of paragraph 2 of this Regulation, except overpressure, external leakage, resistance to dry heat test, ozone ageing.

Annex 4B

PROVISIONS REGARDING THE APPROVAL OF FLEXIBLE FUEL LINES OR HOSES

Scope

The purpose of this annex is to determine the provisions regarding the approval of flexible hoses for use with CNG.

This annex covers three types of flexible hoses:

(i) High pressure hoses (Class 0),
(ii) Medium pressure hoses (Class 1),
(iii) Low pressure hoses (Class 2)

1. HIGH PRESSURE HOSES, CLASS 0 CLASSIFICATION

1.1. General specifications

1.1.1. The hose shall be so designed as to withstand a maximum working pressure of 1.5 times the working pressure (MPa).

1.1.2. The hose shall be so designed as to withstand temperatures as specified in annex 50.

1.1.3. The inside diameter shall be in compliance with table 1 of Standard ISO 1307.

1.2. Hose construction

1.2.1. The hose must embody a smooth-bore tube and a cover of suitable synthetic material, reinforced with one or more interlayer(s).

1.2.2. The reinforcing interlayer(s) has (have) to be protected by a cover against corrosion.

If for the reinforcing interlayer(s) corrosion-resistant-material is used (i.e. stainless-steel) a cover is not required.

1.2.3. The lining and the cover must be smooth and free from pores, holes and strange elements.
An intentionally provided puncture in the cover shall not be considered as an imperfection.

1.2.4. The cover has to be intentionally perforated to avoid the forming of bubbles.

1.2.5. When the cover is punctured and the interlayer is made of a non-corrosion-resistant material, the interlayer has to be protected against corrosion.

1.3. Specifications and tests for the lining

1.3.1. Tensile strength and elongation

1.3.1.1. Tensile strength and elongation at break according to ISO 37. Tensile strength not less than 20 MPa and elongation at break not less than 250 per cent.

1.3.1.2. Resistance to n-pentane according to ISO 1817 with the following conditions:

(i) medium: n-pentane
(ii) temperature: 23°C (tolerance according to ISO 1817)
(iii) immersion period: 72 hours

Requirements:

(i) maximum change in volume 20 per cent
(ii) maximum change in tensile strength 25 per cent
(iii) maximum change in elongation at break 30 per cent

After storage in air with a temperature of 40 °C for a period of 48 hours the mass compared to the original value may not decrease more than 5 per cent.

1.3.1.3. Resistance to ageing according to ISO 188 with the following conditions:

(i) temperature: 70 °C (test temperature = maximum operating temperature - 10 °C)
(ii) exposure period: 168 hours

Requirements:

(i) maximum change in tensile strength 25 per cent
(ii) maximum change in elongation at break -30 per cent and +10 per cent

1.4. Specifications and test-method for the cover

1.4.1. Tensile strength and elongation

1.4.1.1. Tensile strength and elongation at break according to ISO 37. Tensile strength not less than 10 MPa and elongation at break not less than 250 per cent.

1.4.1.2. Resistance to n-hexane according to ISO 1817 with the following conditions:

(i) medium: n-hexane
(ii) temperature: 23 °C (tolerance acc.to ISO 1817)
(iii) immersion period: 72 hours

Requirements:

(i) maximum change in volume 30 per cent
(ii) maximum change in tensile strength 35 per cent
(iii) maximum change in elongation at break 35 per cent

1.4.1.3. Resistance to ageing according to ISO 188 with the following conditions:

(i) temperature: 70 °C (test temperature = maximum operating temperature - 10 °C)
(ii) exposure period: 336 hours

Requirements:

(i) maximum change in tensile strength 25 per cent
(ii) maximum change in elongation at break -30 per cent and +10 per cent

1.4.2. Resistance to ozone

1.4.2.1. The test has to be performed in compliance with Standard ISO 1431/1.

1.4.2.2. The test-pieces, which have to be stretched to an elongation of 20 per cent shall have to be exposed to air of 40 °C with an ozone-concentration of 50 parts per hundred million during 120 hours.

1.4.2.3. No cracking of the test pieces is allowed.

1.5. Specifications for uncoupled hose

1.5.1. Gas-tightness (permeability)

1.5.1.1. A hose at a free length of 1 m has to be connected to a container filled with liquid propane, having a temperature of 23° ± 2 °C.

1.5.1.2. The test has to be carried out in compliance with the method described in Standard ISO 4080.

1.5.1.3. The leakage through the wall of the hose shall not exceed 95 cm^3 per metre of hose per 24 h.

1.5.2. Resistance at low temperature

1.5.2.1. The test has to be carried out in compliance with the method described in Standard ISO 4672-1978, method B.

1.5.2.2. Test-temperature: -25° ± 3 °C.

1.5.2.3. No cracking or rupture is allowed.

1.5.3. Bending test

1.5.3.1. An empty hose, at a length of approximately 3.5 m must be able to withstand 3,000 times the hereafter prescribed alternating-bending-test without breaking. After the test the hose must be capable of withstanding the test-pressure as mentioned in paragraph 1.5.4.2.

1.5.3.2.

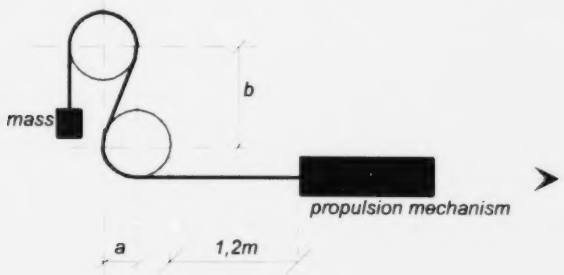


Figure 1 (example only)

Hose inside diameter [mm]	Bending radius [mm] (Figure 1)	Distance between centres [mm] (Figure 1)	
		Vertical b	Horizontal a
up to 13	102	241	102
13 to 16	153	356	153
from 16 to 20	178	419	178

1.5.3.3. The testing-machine (Figure 1) shall consist of a steel frame, provided with two wooden wheels, with a rim-width of c.a. 130 mm.

The circumference of the wheels must be grooved for the guidance of the hose.
The radius of the wheels, measured to the bottom of the groove, must be as indicated in paragraph 1.5.3.2.

The longitudinal median planes of both wheels must be in the same vertical plane and the distance between the wheel-centres must be in accordance with paragraph 1.5.3.2.

Each wheel must be able to rotate freely round its pivot-centre.

A propulsion-mechanism pulls the hose over the wheels at a speed of four complete motions per minute.

1.5.3.4. The hose shall be S-shape-like installed over the wheels (see Figure 1).

The end, that runs over the upper wheel shall be furnished with a sufficient mass as to achieve a complete snuggling of the hose against the wheels. The part that runs over the lower wheel is attached to the propulsion-mechanism.

The mechanism must be so adjusted, that the hose travels a total distance of 1.2 m in both directions.

1.5.4. Hydraulic-test-pressure and appointment of the minimum burst-pressure

1.5.4.1. The test has to be carried out in compliance with the method described in Standard ISO 1402.

1.5.4.2. The test-pressure of 1.5 times the working pressure (MPa) shall be applied during 10 minutes, without any leakage.

1.5.4.3. The burst pressure shall not be less than 45 MPa.

1.6. Couplings

1.6.1. The couplings shall be made from steel or brass and the surface must be corrosion-resistant.

1.6.2. The couplings must be of the crimp-fitting type.

1.6.2.1. The swivel-nut must be provided with U.N.F.-thread.

1.6.2.2. The sealing-cone must be of the type with a half vertical angle of 45°.

1.7. Assembly of hose and couplings

1.7.1. The construction of the couplings must be such, that it is not necessary to peel the cover unless the reinforcement of the hose consists of corrosion-resistant material.

1.7.2. The hose assembly has to be subjected to an impulse test in compliance with Standard ISO 1436.

1.7.2.1. The test has to be completed with circulating oil having a temperature of 93 °C, and a minimum pressure of 26 MPa.

1.7.2.2. The hose has to be subjected to 150,000 impulses.

1.7.2.3. After the impulse-test the hose has to withstand the test-pressure as mentioned in paragraph 1.5.4.2.

1.7.3. Gas-tightness

1.7.3.1. The hose assembly (hose with couplings) has to withstand during five minutes a gas pressure of 1.5 times the working pressure (MPa) without any leakage.

1.8. Markings

1.8.1. Every hose must bear, at intervals of not greater than 0.5 m, the following clearly legible and indelible identification markings consisting of characters, figures or symbols.

1.8.1.1. The trade name or mark of the manufacturer.

1.8.1.2. The year and month of fabrication.

1.8.1.3. The size and type-marking.

1.8.1.4. The identification-marking "CNG Class 0".

1.8.2. Every coupling shall bear the trade name or mark of the assembling manufacturer.

2. MEDIUM PRESSURE HOSES, CLASS 1 CLASSIFICATION

2.1. General specifications

2.1.1. The hose shall be so designed as to withstand a maximum working pressure of 3 MPa.

2.1.2. The hose shall be so designed as to withstand temperatures as specified in annex 5O.

2.1.3. The inside diameter shall be in compliance with table 1 of Standard ISO 1307.

2.2. Hose construction

2.2.1. The hose must embody a smooth-bore tube and a cover of suitable synthetic material, reinforced with one or more interlayer(s).

2.2.2. The reinforcing interlayer(s) has (have) to be protected by a cover against corrosion.

If for the reinforcing interlayer(s) corrosion-resistant-material is used (i.e. stainless-steel) a cover is not required.

2.2.3. The lining and the cover must be smooth and free from pores, holes and strange elements.

An intentionally provided puncture in the cover shall not be considered as an imperfection.

2.3. Specifications and tests for the lining

2.3.1. Tensile strength and elongation

2.3.1.1. Tensile strength and elongation at break according to ISO 37. Tensile strength not less than 10 MPa and elongation at break not less than 250 per cent.

2.3.1.2. Resistance to n-pentane according to ISO 1817 with the following conditions:

(i) medium: n-pentane
(ii) temperature: 23 °C (tolerance acc. to ISO 1817)
(iii) immersion period: 72 hours

Requirements:

(i) maximum change in volume 20 per cent
(ii) maximum change in tensile strength 25 per cent
(iii) maximum change in elongation at break 30 per cent

After storage in air with a temperature of 40 °C for a period of 48 hours the mass compared to the original value may not decrease more than 5 per cent.

2.3.1.3. Resistance to ageing according to ISO 188 with the following conditions:

(i) temperature: 115 °C (test temperature = maximum operating temperature - 10 °C)
(ii) exposure period: 168 hours

Requirements:

(i) maximum change in tensile strength 25 per cent
(ii) maximum change in elongation at break -30 per cent and +10 per cent

2.4. Specifications and test-method for the cover

2.4.1. Tensile strength and elongation

2.4.1.1. Tensile strength and elongation at break according to ISO 37 Tensile strength not less than 10 MPa and elongation at break not less than 250 per cent.

2.4.1.2. Resistance to n-hexane according to ISO 1817 with the following conditions:

(i) medium: n-hexane
(ii) temperature: 23 °C (tolerance acc. to ISO 1817)
(iii) immersion period: 72 hours

Requirements:

(i) maximum change in volume 30 per cent
(ii) maximum change in tensile strength 35 per cent
(iii) maximum change in elongation at break 35 per cent

2.4.1.3. Resistance to ageing according to ISO 188 with the following conditions:

(i) temperature: 115 °C (test temperature = maximum operating temperature -10 °C)
(ii) exposure period: 336 hours

Requirements:

(i) maximum change in tensile strength 25 per cent
(ii) maximum change in elongation at break -30 per cent and +10 per cent

2.4.2. Resistance to ozone

2.4.2.1. The test has to be performed in compliance with Standard ISO 1431/1.

2.4.2.2. The test-pieces, which have to be stretched to an elongation of 20 per cent shall have to be exposed to air of 40 °C with an ozone-concentration of 50 parts per hundred million during 120 hours.

2.4.2.3. No cracking of the test pieces is allowed.

2.5. Specifications for uncoupled hose

2.5.1. Gas-tightness (permeability)

2.5.1.1. A hose at a free length of 1 m has to be connected to a container filled with liquid propane, having a temperature of 23° ± 2 °C.

2.5.1.2. The test has to be carried out in compliance with the method described in Standard ISO 4080.

2.5.1.3. The leakage through the wall of the hose shall not exceed 95 cm^3 per metre of hose per 24 h.

2.5.2. Resistance at low temperature

2.5.2.1. The test has to be carried out in compliance with the method described in Standard ISO 4672-1978, method B.

2.5.2.2. Test-temperature: -25° ± 3 °C.

2.5.2.3. No cracking or rupture is allowed.

2.5.3. Bending test

2.5.3.1. An empty hose, at a length of approximately 3.5 m must be able to withstand 3,000 times the hereafter prescribed alternating-bending-test without breaking. After the test the hose must be capable of withstanding the test-pressure as mentioned in paragraph 2.5.4.2.

2.5.3.2.

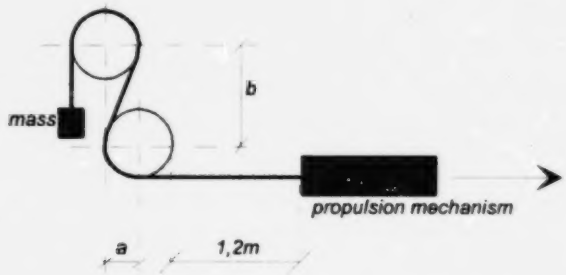


Figure 2 (example only)

Hose inside diameter [mm]	Bending radius [mm] (Figure 2)	Distance between centres [mm] (Figure 2)	
		Vertical b	Horizontal a
up to 13	102	241	102
13 to 16	153	356	153
from 16 to 20	178	419	178

2.5.3.3. The testing-machine (Figure 2) shall consist of a steel frame, provided with two wooden wheels, with a rim-width of c.a. 130 mm.

The circumference of the wheels must be grooved for the guidance of the hose.
The radius of the wheels, measured to the bottom of the groove, must be as indicated in paragraph 2.5.3.2.

The longitudinal median planes of both wheels must be in the same vertical plane and the distance between the wheel-centres must be in accordance with paragraph 2.5.3.2.

Each wheel must be able to rotate freely round its pivot-centre.

A propulsion-mechanism pulls the hose over the wheels at a speed of four complete motions per minute.

2.5.3.4. The hose shall be S-shape-like installed over the wheels (see Figure 2).

The end, that runs over the upper wheel shall be furnished with a sufficient mass as to achieve a complete snuggling of the hose against the wheels. The part that runs over the lower wheel is attached to the propulsion mechanism.

The mechanism must be so adjusted, that the hose travels a total distance of 1.2 m in both directions.

2.5.4. Hydraulic-test-pressure

2.5.4.1. The test has to be carried out in compliance with the method described in Standard ISO 1402.

2.5.4.2. The test-pressure of 3 MPa shall be applied during 10 minutes, without any leakage.

2.6. Couplings

2.6.1. If a coupling is mounted on the hose the following conditions have to be met:

2.6.2. The couplings shall be made from steel or brass and the surface must be corrosion-resistant.

2.6.3. The couplings must be of the crimp-fitting type.

2.7. Assembly of hose and couplings

2.7.1. The construction of the couplings must be such, that it is not necessary to peel the cover unless the reinforcement of the hose consists of corrosion-resistant material.

2.7.2. The hose assembly has to be subjected to an impulse test in compliance with Standard ISO 1436.

2.7.2.1. The test has to be completed with circulating oil having a temperature of 93 °C, and a minimum pressure of 1.5 times the maximum working pressure.

2.7.2.2. The hose has to be subjected to 150,000 impulses.

2.7.2.3. After the impulse-test the hose has to withstand the test-pressure as mentioned in paragraph 2.5.4.2.

2.7.3. Gas-tightness

2.7.3.1. The hose assembly (hose with couplings) has to withstand during five minutes a gas pressure of 3 MPa without any leakage.

2.8. Markings

2.8.1. Every hose must bear, at intervals of not greater than 0.5 m, the following clearly legible and indelible identification markings consisting of characters, figures or symbols.

2.8.1.1. The trade name or mark of the manufacturer.

2.8.1.2. The year and month of fabrication.

2.8.1.3. The size and type marking.

2.8.1.4. The identification-marking "CNG Class 1".

2.8.2. Every coupling shall bear the trade name or mark of the assembling manufacturer.

3. LOW PRESSURE HOSES, CLASS 2 CLASSIFICATION

3.1. General specifications

3.1.1. The hose shall be so designed as to withstand a maximum working pressure of 450 kPa.

3.1.2. The hose shall be so designed as to withstand temperatures as specified in annex 5O.

3.1.3. The inside diameter shall be in compliance with table 1 of Standard ISO 1307.

3.2. (Not allocated)

3.3. Specifications and tests for the lining

3.3.1. Tensile strength and elongation

3.3.1.1. Tensile strength and elongation at break according to ISO 37

Tensile strength not less than 10 MPa and elongation at break not less than 250 per cent.

3.3.1.2. Resistance to n-pentane according to ISO 1817 with the following conditions:

(i) medium: n-pentane
(ii) temperature: 23 °C (tolerance acc. to ISO 1817)
(iii) immersion period: 72 hours

Requirements:

(i) maximum change in volume 20 per cent
(ii) maximum change in tensile strength 25 per cent
(iii) maximum change in elongation at break 30 per cent

After storage in air with a temperature of 40 °C for a period of 48 hours the mass compared to the original value may not decrease more than 5 per cent.

3.3.1.3. Resistance to ageing according to ISO 188 with the following conditions:

(i) temperature: 120 °C (tolerance according to ISO 188)
(ii) exposure period: 168 hours

Requirements:

(i) maximum change in tensile strength 35 per cent
(ii) maximum change in elongation at break -30 per cent and +10 per cent

3.4. Specifications and test-method for the cover

3.4.1. Tensile strength and elongation

3.4.1.1. Tensile strength and elongation at break according to ISO 37

3.4.1.1. Tensile strength not less than 10 MPa and elongation at break not less than 250 per cent.

3.4.1.2. Resistance to n-hexane according to ISO 1817 with the following conditions:

(i) medium: n-hexane
(ii) temperature: 23 °C (tolerance acc. to ISO 1817)
(iii) immersion period: 72 hours

Requirements:

(i) maximum change in volume 30 per cent
(ii) maximum change in tensile strength 35 per cent
(iii) maximum change in elongation at break 35 per cent

3.4.1.3. Resistance to ageing according to ISO 188 with the following conditions:

(i) temperature: 120 °C (tolerance according to ISO 88)
(ii) exposure period: 336 hours

Requirements:

(i) maximum change in tensile strength 25 per cent
(ii) maximum change in elongation at break -30 per cent and +10 per cent

3.4.2. Resistance to ozone

3.4.2.1. The test has to be performed in compliance with Standard ISO 1431/1.

3.4.2.2. The test-pieces, which have to be stretched to an elongation of 20 per cent shall have to be exposed to air of 40 °C and a relative humidity of 50 per cent ± 10 per cent with an ozone concentration of 50 parts per hundred million during 120 hours.

3.4.2.3. No cracking of the test pieces is allowed.

3.5. Specifications for uncoupled hose

3.5.1. Gas-tightness (permeability)

3.5.1.1. A hose at a free length of 1 m has to be connected to a container filled with liquid propane, having a temperature of 23° ± 2 °C.

3.5.1.2. The test has to be carried out in compliance with the method described in Standard ISO 4080.

3.5.1.3. The leakage through the wall of the hose shall not exceed 95 cm^3 per metre of hose per 24 h.

3.5.2. Resistance at low temperature

3.5.2.1. The test has to be carried out in compliance with the method described in Standard ISO 4672, method B.

3.5.2.2. Test-temperature: -25° ± 3 °C.

3.5.2.3. No cracking or rupture is allowed.

3.5.3. Resistance at high temperature

3.5.3.1. A piece of hose, pressurized at 450 kPa, with a minimal length of 0.5 m must be put in an oven at a temperature of 120 °C ± 2 °C during 24 hours.

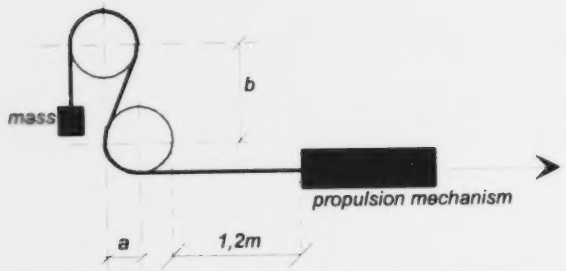
3.5.3.2. No leakage is allowed.

3.5.3.3. After the test the hose shall withstand the test pressure of 50 kPa during 10 minutes. No leakage is allowed.

3.5.4. Bending test

3.5.4.1. An empty hose, at a length of approximately 3.5 m must be able to withstand 3,000 times the hereafter prescribed alternating-bending-test without breaking.

3.5.4.2.



(a = 102 mm; b= 241 mm)

Figure 3 (example only)

The testing machine (Figure 3) shall consist of a steel frame, provided with two wooden wheels, with a rim width of approx. 130 mm.

The circumference of the wheels must be grooved for the guidance of the hose.
The radius of the wheels, measured to the bottom of the groove, must be 102 mm.

The longitudinal median planes of both wheels must be in the same vertical plane. The distance between the wheel-centres must be vertical 241 mm and horizontal 102 mm.

Each wheel must be able to rotate freely round its pivot-centre.

A propulsion-mechanism pulls the hose over the wheels at a speed of four complete motions per minute.

3.5.4.3. The hose shall be S-shape-like installed over the wheels (see Figure 3).

The end, that runs over the upper wheel, shall be furnished with a sufficient mass as to achieve a complete snuggling of the hose against the wheels. The part that runs over the lower wheel is attached to the propulsion mechanism.

The mechanism must be so adjusted, that the hose travels a total distance of 1.2 m in both directions.

3.6. Markings

3.6.1. Every hose must bear, at intervals of not greater than 0.5 m, the following clearly legible and indelible identification markings consisting of characters, figures or symbols.

3.6.1.1. The trade name or mark of the manufacturer.

3.6.1.2. The year and month of fabrication.

3.6.1.3. The size and type marking.

3.6.1.4. The identification marking "CNG Class 2".

3.6.2. Every coupling shall bear the trade name or mark of the assembling manufacturer.

Annex 4C

PROVISIONS REGARDING THE APPROVAL OF THE CNG FILTER

1. The purpose of this annex is to determine the provisions regarding the approval of the CNG filter.

2. Operating conditions

2.1. The CNG filter shall be so designed to operate at temperatures as specified in annex 5O.

2.2. CNG filter shall be Classified with regard to the maximum working pressure (see paragraph 2 of this Regulation):

2.2.1. Class 0: The CNG filter shall be so designed to withstand a pressure of 1.5 times the working pressure (MPa).

2.2.2. Class 1 and Class 2: The CNG filter shall be so designed to withstand a pressure twice the working pressure.

2.2.3. Class 3: the CNG filter shall be so designed to withstand a pressure twice the relief pressure of the pressure relief valve on which it is subject.

2.3. The materials used in the CNG filter which are in contact with CNG when operating, shall be compatible with this gas (see annex 5D).

2.4. The component has to comply with the test procedures for Class components according to the scheme in Figure 1-1 of paragraph 2 of this Regulation.

Annex 4D

PROVISIONS REGARDING THE APPROVAL OF THE PRESSURE REGULATOR

1. The purpose of this annex is to determine the provisions regarding the approval of the pressure regulator.

2. Pressure regulator

2.1. The material constituting the regulator which is in contact with the compressed natural gas when operating shall be compatible with the test CNG. In order to verify this compatibility, the procedure in annex 5D shall be used.

2.2. The materials constituting the regulator which are in contact with the heat exchange medium of the regulator when operating, shall be compatible with that fluid.

2.3. The component shall comply with the test procedures provided for in Class 0 for the parts subject to high pressure and Class 1, 2, 3 and 4 for the parts subject to medium and low pressure.

3. Classification and test pressures

3.1 The part of the pressure regulator which is in contact with the pressure of the container is regarded as Class 0.

3.1.1. The Class 0 part of the pressure regulator shall be leak-proof (see annex 5B) at a pressure up to 1.5 times the working pressure (MPa) with the outlet(s) of that part closed off.

3.1.2. The Class 0 part of the pressure regulator shall withstand a pressure up to 1.5 times the working pressure (MPa).

3.1.3. The Class 1 and Class 2 part of the pressure regulator shall be leak-proof (see annex 5B) at a pressure up to twice the working pressure.

3.1.4. The Class 1 and Class 2 part of the pressure regulator shall withstand a pressure up to twice the working pressure.

3.1.5. The Class 3 part of the pressure regulator shall withstand a pressure up to twice the relief pressure of the pressure relief valve, on which it is subject.

3.2. The pressure regulator shall be so designed to operate at temperatures as specified in annex 5D.

Annex 4E

PROVISIONS REGARDING THE APPROVAL OF THE PRESSURE AND TEMPERATURE SENSORS

1. The purpose of this annex is to determine the provisions regarding the approval of the pressure and temperature sensors.

2. Pressure and temperature sensors

2.1. The material constituting the pressure and temperature sensors which is in contact with the CNG when operating shall be compatible with the test CNG. In order to verify this compatibility, the procedure in annex 5D shall be used.

2.2. The pressure and temperature sensors are Classified in a Class according to the scheme 1-1 in paragraph 2 of this Regulation.

3. Classification and test pressures

3.1 The part of the pressure and temperature sensors which is in contact with the pressure of the container is regarded as Class 0.

3.1.1. The Class 0 part of the pressure and temperature sensors shall be leak-proof at a pressure up to 1.5 times the working pressure (MPa) (see annex 5B).

3.1.2. The Class 0 part of the pressure and temperature sensors shall withstand a pressure up to 1.5 times the working pressure (MPa).

3.1.3. The Class 1 and Class 2 part of the pressure and temperature sensors shall be leak-proof at a pressure up to twice the working pressure (see annex 5B).

3.1.4. The Class 1 and Class 2 part of the pressure and temperature sensors shall withstand a pressure up to twice the working pressure.

3.1.5. The Class 3 part of the pressure and temperature sensors shall withstand a pressure up to twice the relief pressure of the pressure relief valve, on which it is subject.

3.2. The pressure and temperature sensors shall be so designed to operate at temperatures as specified in annex 5O.

3.3. The electrical system, if existing, shall be isolated from the body of the pressure and temperature sensors. Isolation resistance shall be > 10 MΩ.

Annex 4F

PROVISIONS REGARDING THE APPROVAL OF THE FILLING UNIT

1. Scope

The purpose of this annex is to determine the provisions regarding the approval of the filling unit.

2. The filling unit

2.1. The material constituting the filling unit which is in contact with the CNG when the device is in service shall be compatible with the CNG. In order to verify this compatibility, the procedure of annex 5D shall be used.

2.2. The filling unit shall conform to the requirements of Class 0 components.

3. Test pressures.

3.1. The filling unit shall be considered as component of Class 0.

3.1.1. The filling unit shall be free from leakage at a pressure of 1.5 times the working pressure (MPa) (see annex 5B).

3.1.2. The filling unit shall withstand a pressure of 33 MPa.

3.2. The filling unit shall be so designed to operate at temperatures as specified in annex 5O.

Annex 4G

PROVISIONS REGARDING THE APPROVAL OF
GAS FLOW ADJUSTER AND GAS/AIR MIXER OR INJECTOR

1. The purpose of this annex is to determine the provisions regarding the approval of the gas flow adjuster and gas/air mixer or injector.

2. Gas/air mixer or injector

2.1. The material constituting the gas/air mixer or injector which is in contact with CNG shall be compatible with the CNG. In order to verify this compatibility, the procedure specified in annex 5D shall be used.

2.2. The gas/air mixer or injector shall conform to the requirements of Class 1 or 2 components, according to their Classification.

2.3. Test pressures

2.3.1. The gas/air mixer or injector of Class 2 shall withstand a pressure twice the working pressure.

2.3.1.1. The gas/air mixer or injector of Class 2 shall be free from leakage at a pressure twice the working pressure.

2.3.2. The gas/air mixer or injector of Class 1 and Class 2 shall be so designed to operate at temperatures as specified in annex 5O.

2.4. Electrical operated components containing CNG shall comply with the following:

(i) They shall have a separate ground connection;

(ii) The electrical system of the component shall be isolated from the body;

(iii) The injector shall be in closed position when the electric current is switched off.

3. Gas flow adjuster

3.1. The material constituting the gas flow adjuster which is in contact with the CNG shall be compatible with the CNG. In order to verify this compatibility the procedure specified in annex 5D has to be used.

3.2. The gas flow adjuster shall conform to requirements of Class 1 or 2 components, according to their Classification.

3.3. Test pressures

3.3.1. The gas flow adjuster of Class 2 shall withstand a pressure twice the working pressure.

3.3.1.1. The gas flow adjuster of Class 2 shall be free from leakage at a pressure twice the working pressure.

3.3.2. The gas flow adjuster of Class 1 and Class 2 shall be so designed to operate at temperatures as specified in annex 5O.

3.4. Electrical operated components containing CNG shall comply with the following:

(i) They shall have a separate ground connection;

(ii) The electrical system of the component shall be isolated from the body.

Annex 4H

PROVISIONS REGARDING THE APPROVAL OF THE ELECTRONIC CONTROL UNIT

1. The purpose of this annex is to determine the provisions regarding the approval of the electronic control unit.

2. Electronic control unit

2.1. The electronic control unit can be any device which controls the CNG demand of the engine and establishes the cut-off of the automatic valve in case of a broken fuel supply pipe or in case of stalling of the engine, or during a crash.

2.2. The switching off delay of the automatic valve after stalling of the engine may not be more than 5 seconds.

2.3. The device may be equipped with an automatic ignition advance timing adjuster integrated in the electronic module or separated.

2.4. The device may be integrated with dummy injectors to permit a correct functioning of the gasoline electronic control unit during CNG operation.

2.5. The electronic control unit shall be so designed to operate at temperatures as specified in annex 5O.

Annex 5

TEST PROCEDURES

1. Classification

1.1. CNG components for use in vehicles shall be Classified with regard to the maximum working pressure and function, according to paragraph 2 of this Regulation.

1.2 The Classification of the components determines the tests which have to be performed for type-approval of the components or parts of the components.

2. Applicable test procedures

In table 5.1 below the applicable test procedures dependent on the Classification are shown.

Table 5.1

Test	Class 0	Class 1	Class 2	Class 3	Class 4	Paragraph
Overpressure or strength	X	X	X	X	O	5A
External leakage	X	X	X	X	O	5B
Internal leakage	A	A	A	A	O	5C
Durability tests	A	A	A	A	O	5L
CNG compatibility	A	A	A	A	A	5D
Corrosion resistance	X	X	X	X	X	5E
Resistance to dry heat	A	A	A	A	A	5F
Ozone ageing	A	A	A	A	A	5G
Burst/destructive tests	X	O	O	O	O	5M
Temperature cycle	A	A	A	A	O	5H
Pressure cycle	X	O	O	O	O	5I
Vibration resistance	A	A	A	A	O	5N
Operating temperatures	X	X	X	X	X	5O

X = Applicable
O = Not applicable
A = As applicable

The materials used for the components shall have written specifications that fulfil at least or exceed the (test) requirements laid down in this annex with respect to:

(i) temperature
(ii) pressure
(iii) CNG compatibility
(iv) durability

3. General requirements

3.1. Leakage tests shall have to be conducted with pressurized gas like air or nitrogen.

3.2. Water or another fluid may be used to obtain the required pressure for the hydrostatic strength test.

3.3. The test period for leakage- and hydrostatic strength-tests shall be not less than 3 minutes.

Annex 5A

OVERPRESSURE TEST (STRENGTH TEST)

1. A CNG containing component shall withstand without any visible evidence of rupture or permanent distortion a hydraulic pressure of 1.5-2 times the maximum working pressure during minimal 1 minute at room temperature with the outlet of the high pressure part plugged. Water or any other suitable hydraulic fluid may be used as a test medium.

2. The samples, previously subjected to the durability test of annex 5L are to be connected to a source of hydrostatic pressure. A positive shut-off valve and a pressure gauge, having a pressure of not less than 1.5 times nor more than 2 times the test pressure, are to be installed in the hydrostatic pressure supply piping.

3. Table 5.2 below shows the working and burst test pressures according to the Classification of paragraph 2 of this Regulation.

Table 5.2

Classification of component	Working pressure [kPa]	Overpressure [kPa]
Class 0	3000<p<26000	1.5 times the working pressure
Class 1	450<p<3000	1.5 times the working pressure
Class 2	20<p<450	2 times the working pressure
Class 3	450<p<3000	2 times the relief pressure

Annex 5B

EXTERNAL LEAKAGE TEST

1. A component shall be free from leakage through stem or body seals or other joints, and shall not show evidence of porosity in casting when tested as described in paragraphs 2. and 3. of this annex at any aerostatic pressure between 0 and the pressure shown in table 5.2.

2. The test shall be performed at the following conditions:

(i) at room temperature
(ii) at the minimum operating temperature
(iii) at the maximum operating temperature

The maximum and minimum operating temperatures are given in annex 5O.

3. During this test the equipment under test (EUT) will be connected to a source of aerostatic pressure. An automatic valve and a pressure gauge having a pressure range of not less than 1.5 times nor more than 2 times the test pressure are to be installed in the pressure supply piping. The pressure gauge is to be installed between the automatic valve and the sample under test. While under the applied test pressure, the sample should be submerged in water to detect leakage or any other equivalent test method (flow measurement or pressure drop).

4. The external leakage must be lower than the requirements stated in the annexes or if no requirements are mentioned the external leakage shall be lower than 15 cm^3/hour.

5. High temperature test

A CNG containing component shall not leak more than 15 cm^3/hour with the outlet plugged when submitted to a gas pressure, at maximum operating temperature as indicated in annex 5O, equal to the maximum working pressure. The component shall be conditioned for at least 8 hours at this temperature.

6. Low temperature test

A CNG containing component shall not leak more than 15 cm^3/hour with the outlet plugged when submitted to a gas pressure, at the minimum operating temperature, equal to the maximum working pressure as declared by the manufacturer. The component shall be conditioned for at least 8 hours at this temperature.

Annex 5C

INTERNAL LEAKAGE TEST

1. The following tests are to be conducted on samples of valves or filling unit which have previously been subjected to the external leak test of annex 5B above.

2. The seat of the valves, when in the closed position, shall be free from leakage at any aerostatic pressure between 0 to 1.5 times the working pressure (kPa).

3. A non-return valve provided with a resilient seat (elastic), when in the closed position, shall not leak when subjected to any aerostatic pressure between 0 and 1.5 times the working pressure (kPa).

4. A non-return valve provided with a metal-to-metal seat, when in the closed position, shall not leak at a rate exceeding 0.47 dm^3/s when subjected to an aerostatic pressure difference of 138 kPa effective pressure.

5. The seat of the upper non-return valve used in the assembly of a filling unit, when in the closed position, shall be free from leakage at any aerostatic pressure between 0 and 1.5 times the working pressure (kPa).

6. The internal leakage tests are conducted with the inlet of the sample valve connected to a source of aerostatic pressure, the valve in the closed position, and with the outlet open. An automatic valve and a pressure gauge having a pressure range of not less than 1.5 times nor more than 2 times the test pressure are to be installed in the pressure supply piping. The pressure gauge is to be installed between the automatic valve and the sample under test. While under the applied test pressure, observations for leakage are to be made with the open outlet submerged in water unless otherwise indicated.

7. Conformance with paragraphs 2. to 5. is to be determined by connecting a length of tubing to the valve outlet. The open end of this outlet tube is to be located within an inverted graduated cylinder which is calibrated in cubic centimetres. The inverted cylinder is to be closed by a water tight seal. The apparatus is to be adjusted so that:

   (1) the end or the outlet tube is located approximately 13 mm above the water level within the inverted graduated cylinder, and

   (2) the water within and exterior to the graduated cylinder is at the same level. With these adjustments made, the water level within the graduated cylinder is to be recorded. With the valve in the closed position assumed as the result of normal operation, air or nitrogen at the specified test pressure is to be applied to the valve inlet for a test

period of not less than 2 minutes. During this time, the vertical position of the graduated cylinder is to be adjusted, if necessary, to maintain the same water level within and exterior to it.

At the end of the test period and with the water within and exterior to the graduated cylinder at the same level, the level of water within the graduated cylinder is again recorded. From the change of volume within the graduated cylinder, the leakage rate is to be calculated according to the following formula:

$$V_1 = V_t \cdot \frac{60}{t} \cdot \left(\frac{273}{T} \cdot \frac{P}{101.6} \right)$$

where:

V_1 = leakage rate, cubic centimetres of air or nitrogen per hour.

V_t = increase in volume within graduated cylinder during test.

t = time of test, minutes.

P = barometric pressure during test, in kPa.

T = ambient temperature during test, in K.

8. Instead of the method described above, leakage may be measured by a flowmeter installed on the inlet side of the valve under test. The flowmeter shall be capable of indicating accurately, for the test fluid employed, the maximum leakage flow rates permitted.

Annex 5D

CNG COMPATIBILITY TEST

1. A synthetic part in contact with CNG shall not show excessive volume change or loss of weight.
Resistance to n-pentane according to ISO 1817 with the following conditions:

(i) medium: n-pentane
(ii) temperature: 23 °C (tolerance acc.to ISO 1817)
(iii) immersion period: 72 hours

2. Requirements:

maximum change in volume 20 per cent

After storage in air with a temperature of 40 °C for a period of 48 hours the mass compared to the original value may not decrease more than 5 per cent.

Annex 5E

CORROSION RESISTANCE TEST

1. A metal CNG containing component shall comply with the leakage tests mentioned in annexes 5B and 5C and after having been submitted to 144 hours salt spray test according to ISO CD 15500-2, with all connections closed.

Test procedure:

Before the test the component shall be cleaned according to the instructions of the manufacturer. All the connections shall be closed off. The component shall not be operated during the test.

Subsequently the component shall be submitted during 2 hours to spraying with a solution of salt, containing 5 per cent NaCl (mass per cent) with less than 0.3 per cent contamination and 95 per cent distilled or demineralised water, at a temperature of 20 °C. After the spraying the component is stored at temperature of 40 °C and 90-95 per cent relative humidity for 168 hours. This sequence shall be repeated 4 times.

After the test the component shall be cleaned and dried during 1 hour at 55 °C. The component shall now be conditioned to reference conditions during 4 hours, before submitting it to further testing.

2. A copper or brass CNG containing component shall comply with the leakage tests mentioned in annexes 5B and 5C and after having been submitted to 24 hours immersion in ammonia according to ISO CD 15500-2 with all connections closed.

Annex 5F

RESISTANCE TO DRY HEAT

1. The test has to be done in compliance with ISO 188. The test piece has to be exposed to air at a temperature equal to the maximum operating temperature for 168 hours.

2. The allowable change in tensile strength should not exceed + 25 per cent. The allowable change in ultimate elongation shall not exceed the following values:

   Maximum increase 10 per cent
   Maximum decrease 30 per cent

Annex 5G

OZONE AGEING

1. The test has to be in compliance with ISO 1431/1.

The test piece, which has to be stressed to 20 per cent elongation shall be exposed to air at 40°C with an ozone concentration of 50 parts per hundred million during 120 hours.

2. No cracking of the test piece is allowed.

Annex 5H

TEMPERATURE CYCLE TEST

A non metallic part containing CNG shall comply with the leakage tests mentioned in annexes 5B and 5C after having been submitted to 96 hours temperature cycle from the minimum operating temperature up to the maximum operating temperature with a cycle time of 120 minutes, under maximum working pressure.

Annex 5I

PRESSURE CYCLE TEST APPLICABLE ONLY TO CYLINDERS (SEE ANNEX 3)

Annexes 5J and 5K - Not allocated

Annex 5L

DURABILITY TEST (CONTINUED OPERATION)

Test method

The component shall be connected to a source of pressurised dry air or nitrogen by means of a suitable fitting and subjected to the number of cycles specified for that specific component. A cycle shall consist of one opening and one closing of the component within a period of not less than 10 ± 2 seconds.

(a) Room temperature cycling

The component shall be operated through 96 per cent of the total cycles at room temperature and at rated service pressure. During the off cycle the down stream pressure of the test fixture should be allowed to decay to 50 per cent of the test pressure. After that, the components shall comply with the leakage test of annex 5B at room temperature. It is allowed to interrupt this part of the test at 20 per cent intervals for leakage testing.

(b) High temperature cycling

The component shall be operated through 2 per cent of the total cycles at the appropriate maximum temperature specified at rated service pressure. The component shall comply with the leakage test of annex 5B at the appropriate maximum temperature at the completion of the high temperature cycles.

(c) Low temperature cycling

The component shall be operated through 2 per cent of the total cycles at the appropriate minimum temperature specified at rated service pressure. The component shall comply with the leakage test of annex 5B at the appropriate minimum temperature specified at the completion of the low temperature cycles.

Following cycling and leakage re-test, the component shall be capable of completely opening and closing when a torque not greater than that specified in Table 5.3 is applied to the component handle in a direction to open it completely and then in the reverse direction.

Table 5.3

Component inlet size (mm)	Max. torque (Nm)
6	1.7
8 or 10	2.3
12	2.8

This test shall be conducted at the appropriate maximum temperature specified, and shall be repeated at a temperature of -40 °C.

Annex 5M

BURST/DESTRUCTIVE TEST APPLICABLE ONLY TO CYLINDERS (SEE ANNEX 3)

Annex 5N

VIBRATION RESISTANCE TEST

All components with moving parts shall remain undamaged, continue to operate, and comply with the component's leakage tests after 6 hours of vibration in accordance with the following test method.

Test method

The component shall be secured in an apparatus and vibrated for 2 hours at 17 Hz with an amplitude of 1.5 mm (0,06 in.) in each of three orientation axes. On completion of 6 hours of vibration the component shall comply with annex 5C.

Annex 50

OPERATING TEMPERATURES

	Engine Compartment	On board
Moderate	-20 °C ÷ +120 °C	-20 °C ÷ +85 °C
Cold	-40 °C ÷ +120 °C	-40 °C ÷ +85 °C

Annex 6

PROVISIONS REGARDING CNG IDENTIFICATION MARK FOR PUBLIC SERVICE VEHICLES

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The sign consists of a sticker which must be weather resistant.

The colour and dimensions of the sticker must fulfil the following requirements:

Colours:

Background:	green
Border:	white or white reflecting
Letters:	white or white reflecting

Dimensions

Border width:	4 - 6 mm
Character height:	≥ 25 mm
Character thickness:	≥ 4 mm
Sticker width:	110 - 150 mm
Sticker heignt:	80 - 110 mm

The word "CNG" must be centred in the middle of the sticker.